



## **Intermountain Region Risk Management Office** ***Safety and Health Site Visit and Evaluation Report***

To: Bill Wellman, Superintendent, Curecanti/Black Canyon of the Gunnison (CURE-BLCA)  
Linda Alick, Chief Ranger, CURE-BLCA  
Jerry Burgess, Facility Manager, CURE-BLCA  
Danguole Bockus, Ecologist, CURE-BLCA

CC: David Bleicher, NPS Washington Occupational Health Manager  
Oly Olson, IMR Regional Risk Manager  
Mary O'Brian, Assistant Regional Director-Program Review, IMR

From: Jennifer Sahmel, IMR Occupational Health Manager

Date: September 22, 2004

Re: Carbon Monoxide Exposure Monitoring during CURE Boat Operations

### **A. SUMMARY**

On June 8 and 9, 2004, the Intermountain Region's Occupational Health Manager, Jennifer Sahmel, and the NPS-Washington Occupational Health Manager, David Bleicher, visited CURE to evaluate carbon monoxide exposures during boat operations, both on the water and in the maintenance and operations areas of the park.

#### **Risks and Symptoms of Carbon Monoxide Exposure**

Carbon monoxide (CO) is a common component of boat and recreational vehicle exhaust, and under certain conditions it can reach levels that are immediately dangerous to life and health very quickly, even outdoors. CO poses an even greater risk in enclosed spaces on boats, such as inside cabin areas. The levels of CO seen for recreational vehicles and boats are typically much higher than those found in standard car or truck exhaust because devices such as catalytic converters and safety instruments reduce the CO levels significantly in the exhaust of these types of vehicles. Symptoms of CO exposure include headaches, nausea, dizziness, confusion, weakness, and at higher exposures, hallucination, blue lips, coma, and death.

#### **Established Exposure Limits for CO**

CO can be hazardous at concentrations well below those levels commonly seen in boat and recreational vehicle exhaust. The Occupational Safety and Health Administration's (OSHA's) permissible exposure limit (PEL) for exposure to carbon monoxide over a continuous, 8-hour work shift as a time-weighted average is 50 parts per million (ppm). The National Institute for Occupational Safety and Health (NIOSH) has a lower Recommended Exposure Limit (REL) of 35 ppm over an 8-hour work shift, and also has an instant-reading or ceiling REL of 200 ppm at any given point during the work shift. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends an 8-hour Threshold Limit Value (TLV) of 25 ppm.

## **Park Evaluation**

This report includes findings and recommendations for carbon monoxide exposures measured on most of the park's boats and in several additional areas of the park. Monitoring was conducted at the following locations:

- On the tour boat at the Pine Creek boat dock,
- On a ranger boat at the Morrow Point Dam during tour boat refueling and subsequent patrols,
- In the boat maintenance shop at Elk Creek,
- At the Elk Creek Marina on the boat launch ramp during park boat engine maintenance,
- On the maintenance barge,
- On two ranger boats on Blue Mesa Reservoir during routine patrols, and
- During seasonal boat training at the Elk Creek Marina.

Of particular concern were CO levels on the maintenance barge, in the cabin of the cabin cruiser ranger boat, and in the boat maintenance shop when the exhaust system was not running during engine work. CO levels were also of concern on the ranger patrol boats on the Blue Mesa Reservoir for certain wind directions. In particular, levels during startup of the maintenance barge reached over 800 ppm within several seconds, an extremely dangerous level. Levels in the cabin of the cabin cruiser spiked up to 376 ppm during idling on the reservoir when the wind direction was from the back of the boat. In the maintenance shop, CO levels spiked up to 277 ppm within only 5 seconds if a boat engine was idled in the shop without the test tank ventilation system on. On the ranger patrol boats in the operator area, levels spiked as high as 380 ppm during routine patrols.

In all four of these situations, CO concentrations quickly reached a level that posed an immediate danger to the health of employees in the area. Because of the high risk that carbon monoxide exposure poses, all employees working at the park should be aware of the potential dangers of exhaust buildup and high CO exposure. Final recommendations at the end of this report include that employee awareness training should be conducted to make all employees aware of the risks of CO exposure, and to ensure that employees understand the variability of CO exposures based on wind direction and position on the boat. Additionally, the park should install CO detectors on all boats at CURE to ensure that employees are alerted if CO concentrations reach dangerous levels.

## **B. ASSESSMENT**

All carbon monoxide sampling was conducted using Biosystems Toxi Ultra carbon monoxide units, which conduct both direct reading and logging of carbon monoxide concentrations.

### **1. Pine Creek Tour Boat**

The Pine Creek Tour Boat is powered by twin outboard Johnson Bombardiers at 140 horsepower (HP). Both units are electronic fuel-injected 4-stroke engines. Public tours are offered daily on the boat during the summer season on the Morrow Point Reservoir. Two park staff members typically run the boat; one staff member is the boat operator, while the other provides interpretive information during the ride. Neither operator must spend very much time at the rear of the boat, where the engines are located. Monitoring was conducted on this boat on June 8 because a refueling trip to the Morrow Point Dam was scheduled. Monitoring for CO was conducted for both of the staff members on the boat, Mr. Ron Walton and Mr. Miles Kinne. Monitoring was also conducted for Mr. Bleicher, who remained on the boat during the trip to refuel and the return to the Pine Creek Dock.



**Pine Creek Tour Boat**



**Tour Boat Engines**

During the monitoring period (approximately 8:45am to 1:25pm) instantaneous peak exposures to CO were in the range of 15-65 ppm, while average exposures over the time period ranged from 1 to 2 ppm. An instantaneous reading using a Draeger tube showed a CO level of 5 ppm at the rear of the boat near the engines during normal boat speed. Pre-shift expired breath CO levels were 3 ppm (0.9%) for Mr. Walton and 2 ppm (0.5%) for Mr. Kinne. Expired CO levels were the same at the end of the shift. Based on these results, it is unlikely that employee exposures on the Pine Creek Tour Boat will exceed the required or recommended limits for CO during normal operations. Please see Charts I, II, and III below for complete CO exposure data on these three individuals over the monitoring period.

**Chart I: Ron Walton - Tour Boat 6-8-04**

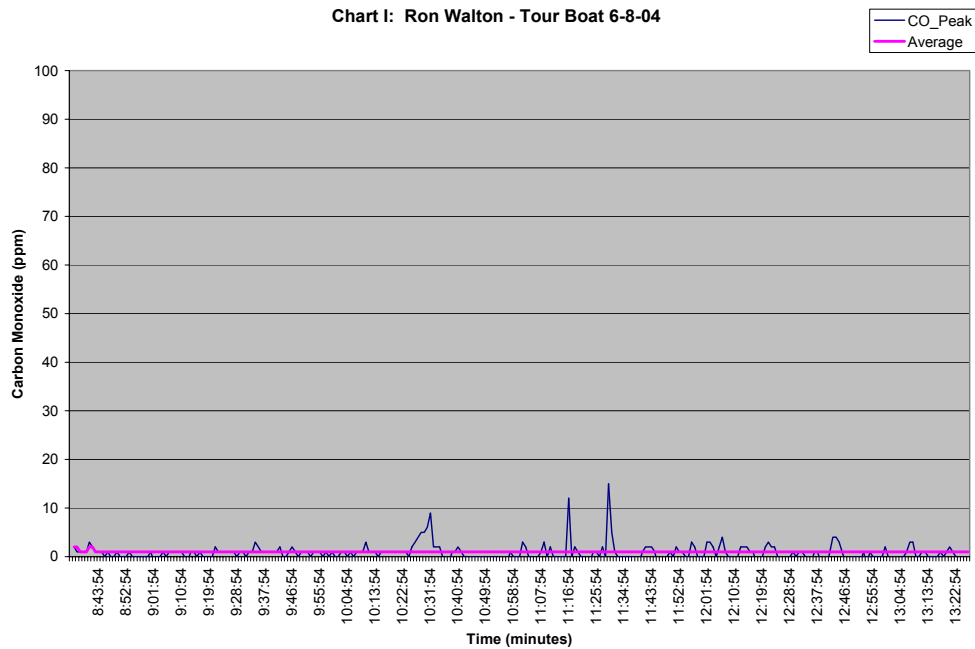


Chart II: Miles Kinne - Tour Boat 6-8-04

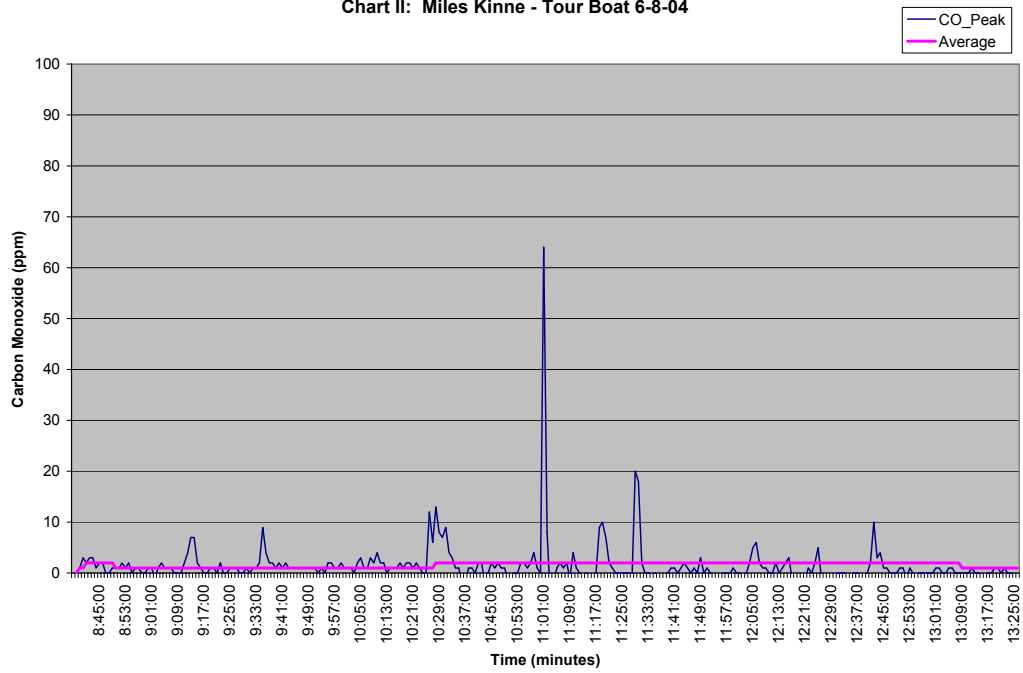
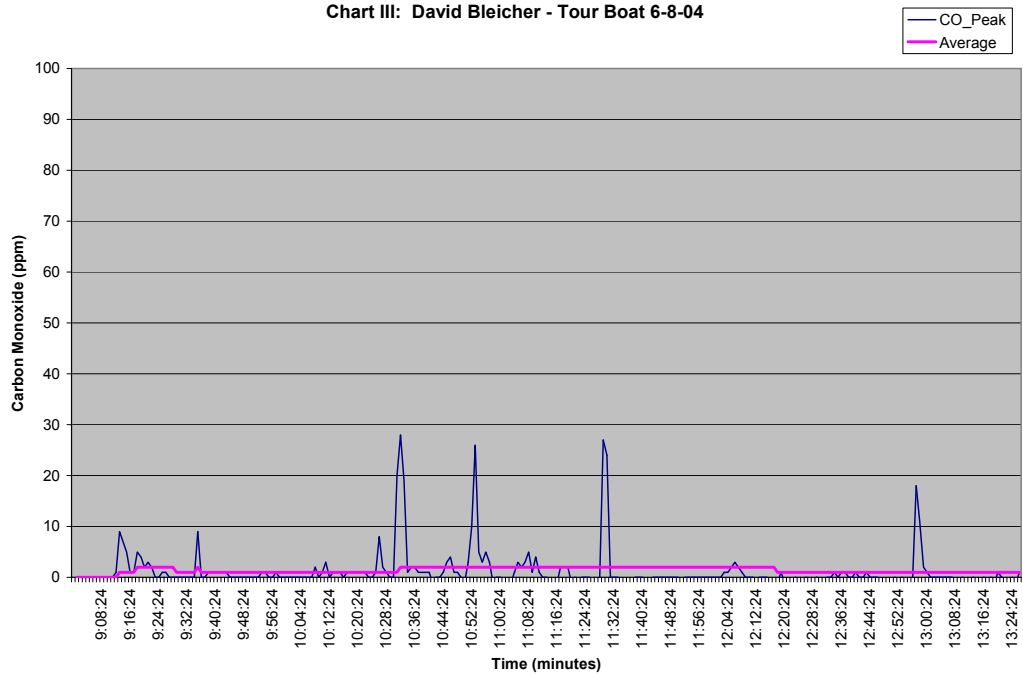


Chart III: David Bleicher - Tour Boat 6-8-04



## 2. Morrow Point Ranger Boat

The Morrow Point Ranger Boat that was monitored is a small open craft with an *inboard/outboard (I/O)* Mercruiser Alpha One 3.0 Liter single engine that was not fuel-injected. Two rangers were assigned to the Morrow Point Reservoir during refueling of the Pine Creek Tour Boat. Because refueling is done at the Morrow Point Dam, the security fence on the water protecting the dam must be opened and monitored by the rangers. The two rangers on the boat on June 8 were Mr. Joel Cadoff and Ms. Shawn Cigrand. According to Mr. Cadoff and Ms. Cigrand, boat rangers typically spend about 1-5 hours per day on the water during patrols and other activities. They indicated that the rangers can also do some scuba work when needed for recovery operations. However, Chief Ranger Linda Alick indicated that no one in the park is currently certified for SCUBA operations, and therefore this type of work is not currently being done at the park. On this particular day Mr. Cadoff and Ms. Cigrand monitored the dam and the dam security fence during refueling, and then conducted a routine patrol on the Morrow Point Reservoir. CO monitoring data was collected for Ms. Cigrand, Mr. Cadoff, and also Ms. Sahmel who rode in the ranger boat following refueling of the tour boat and during the ranger patrol.



**Morrow Point Ranger Boat**



**Ranger and Tour Boats at Dam**

During the monitoring period (approximately 10:35am to 12:35pm) instantaneous peak exposures to CO exceeded the 8-hour exposure alarm on the monitoring equipment, but did not exceed the allowable exposure limit for the entire monitoring period. The NIOSH Ceiling REL of 200 ppm was exceeded on two occasions. Peak exposures ranged from 75 to 275 ppm. Exposures were highest during boat engine warm-up at the dam dock, during closure of the dam security gate and during any slow-speed idle. When the boat moved at higher speeds on the water, exposures dropped to 0-1 ppm. Eight-hour average exposures were 1-5 ppm. End of shift expired breath CO levels were 5 ppm (0.9%) for Mr. Cadoff, 4 ppm (0.7%) for Ms. Cigrand, and 3 ppm (0.5%) for Ms. Sahmel. These levels are considered consistent with normal background concentrations of CO. Although 8-hour exposures were not exceeded, it is likely that rangers working on this type of boat will regularly exceed the NIOSH Ceiling REL of 200 ppm. Please see Charts IV, V, and VI below for complete CO exposure data on these three individuals over the monitoring period.

Chart IV: Jennifer Sahmel - Tour and Ranger Boats 6-8-04

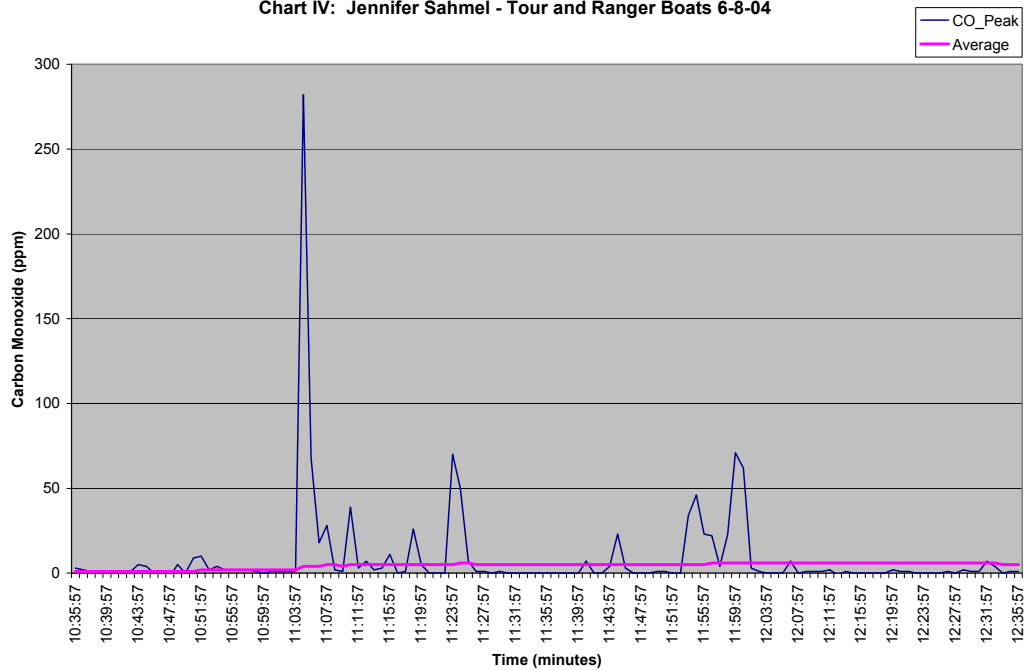
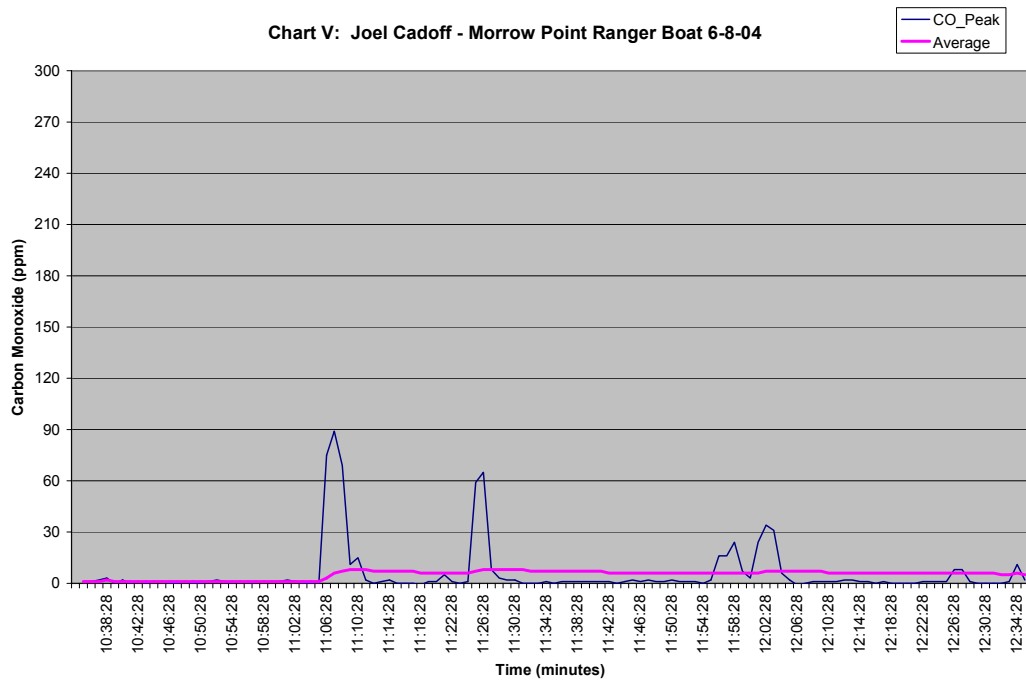


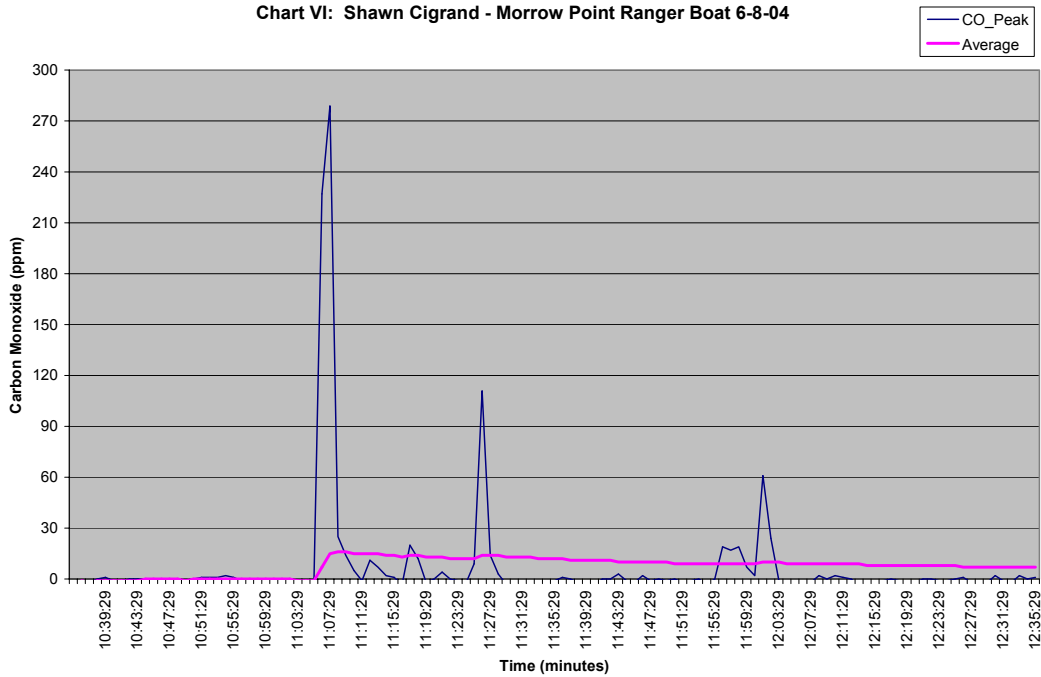
Chart V: Joel Cadoff - Morrow Point Ranger Boat 6-8-04



**Comment [DPB1]:** how about inserting arrows with brief note on the activity. Example: starting and warming engines... docking...

in order to relate peaks to specific activities...

Chart VI: Shawn Cigrand - Morrow Point Ranger Boat 6-8-04



### 3. Curecanti Boat Maintenance Shop at Elk Creek

The boat maintenance shop at Elk Creek is a large, 4-bay enclosed shop dedicated to boat maintenance. Mike Kinkead is the primary boat mechanic, and does the majority of boat engine repair and maintenance for the park at his shop. Mr. Kinkead indicated that he only runs boat engines inside the shop when they are placed inside a ventilated engine test tank in the northwest corner of the shop. He indicated that all engines must be submerged in water in order to run. The engine test tank is a boat engine-specific ventilation system made by Specialty Motors Manufacturing. It is a fully enclosed tank and ventilation duct, with an opening only at the point where engines can be placed into the tank using a hydraulic lift.



Engine Test Tank in Boat Maintenance Shop



Ventilated Test Tank

With the ventilation system running and the test engine at an idle, CO measurements were taken outside the tank in the breathing zone of the operator and were found to be 0 ppm. With the test engine revved up to full throttle, the CO concentration reached 32 ppm. Mr. Kinkead indicated that he will typically run an engine in the test tank for approximately 2 minutes at any given time, and that the boat engine that was used during the test is typical of the type of engine that he would normally test in the tank. These measurements indicate that the ventilation system is currently adequate for the needs of the shop. As a test to determine the effectiveness level of the ventilation system, CO concentrations were also measured with the ventilation system off, and the test engine revved to full throttle. The concentration in the breathing zone of the operator reached 277 ppm within 5 seconds, and spike up to 800 ppm within a minute. This test showed that the ventilation system must always be used when operating engines inside the shop. Mr. Kinkead also indicated that many of the boat motors in the park cannot be tested in the test tank in the shop because they are too large. These must be tested in the water at one of the marinas.

## 5. Testing of Interpretation Staff Boat

On June 9, 8:20-8:35am, Mr. Kinkead conducted testing and maintenance on the Interpretation staff boat, a Boston whaler with an outboard Johnson 90 HP engine. He took the boat to the Elk Creek marina boat ramp to test the engine. During engine testing, CO levels in the breathing zone of Mr. Kinkead quickly reached 87 ppm at lower engine speeds, and rose above 150 ppm at higher engine speeds. The average concentration during the maintenance work, which lasted about 10 minutes, was approximately 20 ppm. The short duration of this particular exposure meant that exposure levels of concern were not reached. Please see Chart VII for Mr. Kinkead's total exposures during maintenance activities.



Maintenance Work at Elk Creek Marina

**Comment [DPB2]:** So who is this guy we see always just standing around?

## 4. Maintenance Barge on Blue Mesa Reservoir

The Curecanti Maintenance Barge is a large metal barge with twin 3-Liter Mercruiser inboard/outboard engines. Each of the engines is 130 HP, and is carbureted rather than fuel-injected. Mr. Kinkead put in the boat at 9:35am, and ran the bilge fans for approximately 5 minutes before starting the engines. This barge is used for maintenance activities on the Blue Mesa Reservoir, such as dock maintenance. Mr. Kinkead indicated that he may operate this boat for anywhere from several minutes to several hours a day. Additionally, noise levels were measured on this boat and were also



found to be a potential concern. Levels ranged from 87 to 92 decibels on the A-weighting scale (dBA) while running at higher speeds, and from 71 to 80 dBA when running at lower speeds. The OSHA and NPS Action Level for noise exposure is 85 dBA over an 8-hour period, which could potentially be reached during longer operations on the barge.



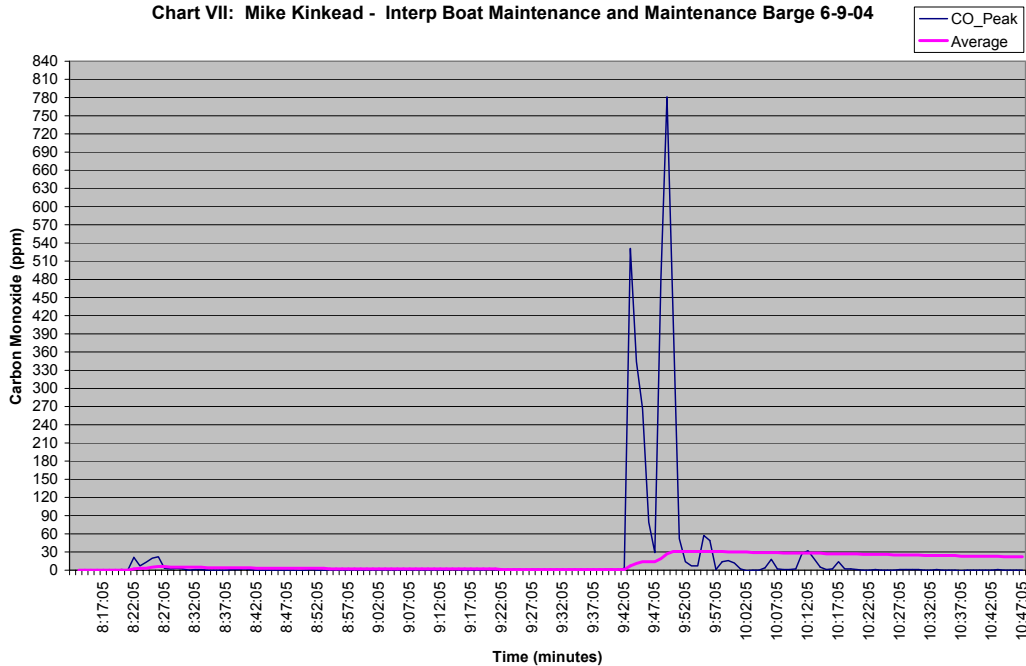
**Maintenance Barge**



**Maintenance Barge Engines**

Immediately after starting the engines at 9:42am, CO levels in the rear of the barge at the operator's controls quickly reached 800 ppm, four times the NIOSH Ceiling REL. Levels remained in the range of 250-750 for approximately 10 minutes. Following startup of the barge and during movement on the barge, levels dropped to 0-60 ppm for the operator. Mr. Kinkead's time-weighted average exposure during all boat maintenance activities was 7 ppm, and his end of shift expired breath CO level was 4 ppm (0.7%), which was consistent with normal background levels of CO. Although Mr. Kinkead's exposure did not exceed 8-hour exposure levels, it greatly exceeded the NIOSH Ceiling REL of 200 ppm. Please see Chart VII below for complete CO exposure data for Mr. Kinkead over the monitoring period.

Chart VII: Mike Kinhead - Interp Boat Maintenance and Maintenance Barge 6-9-04



## 5. Ranger Patrol Boats on Blue Mesa Reservoir

During the summer months, rangers frequently patrol the Blue Mesa Reservoir by boat to monitor fishing license compliance and other regulations. At the time of monitoring on June 9, the ranger staff used two boats to conduct patrols: a 22-foot Boston whaler (*Hawk*) with twin 115 HP Mercury four-stroke electronic fuel-injected engines and a cabin cruiser with twin Johnson 115 HP two-stroke carbureted engines. According to Ms. Alick, the cabin cruiser is slated to be replaced at the end of the summer season. Typically one to two rangers conduct patrols in a single boat. On June 9, Jason Tillotson and Joel Cadoff were the two rangers assigned to patrol the Blue Mesa Reservoir, and demonstrated their typical activities by taking Mr. Bleicher and Ms. Sahmel out on patrols in each of the two ranger boats.

**Boston whaler:** During engine startup, CO levels were low (0-1 ppm) on the Boston whaler. CO levels remained low at all speeds across the water, until the boat was idled to maintain a specific position and communicate with other boats. CO levels quickly rose to 50 ppm during idling, and peaked at 376 ppm during one routine contact session with another boat. Wind direction was directly linked to CO levels in the boat passengers' breathing zone, and CO levels appeared to be highest when the boat was directly in line with the wind. When the boat was idled at an angle to the wind direction, CO levels remained much lower.

**Cabin cruiser:** During engine startup, CO levels rose higher than on the Boston whaler. Levels were measured in the range of 45-90 ppm in the middle of the boat. However, when the wind direction and speed changed slightly, the CO level quickly rose to between 375 and 400 ppm, especially while backing the boat away from the dock. The wind speed is a particularly important issue on the cabin

cruiser, because when the wind blew from the rear of the boat directly into the cabin, CO levels spiked above 450 ppm in under a minute. This is potentially a very dangerous situation because the CO concentrations can build up in the cabin and remain high for longer periods of time.



**The Two Ranger Boats at Elk Creek Marina**



**Boston Whaler Ranger Boat**

During the monitoring period on June 9, Mr. Tillotson's time-weighted average exposure was 3 ppm, and his peak exposure was 191 ppm. Mr. Cadoff's time-weighted average exposure was also 3 ppm, and his peak exposure was 281 ppm.

Chart VIII: Jason Tillotson - Ranger Boats 6-9-04

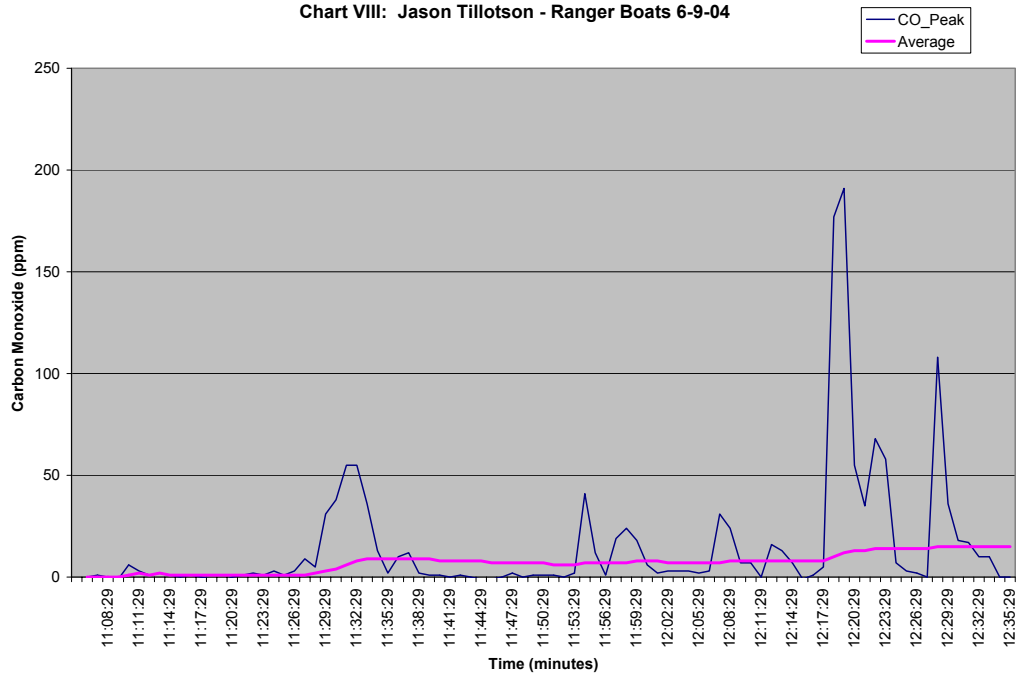
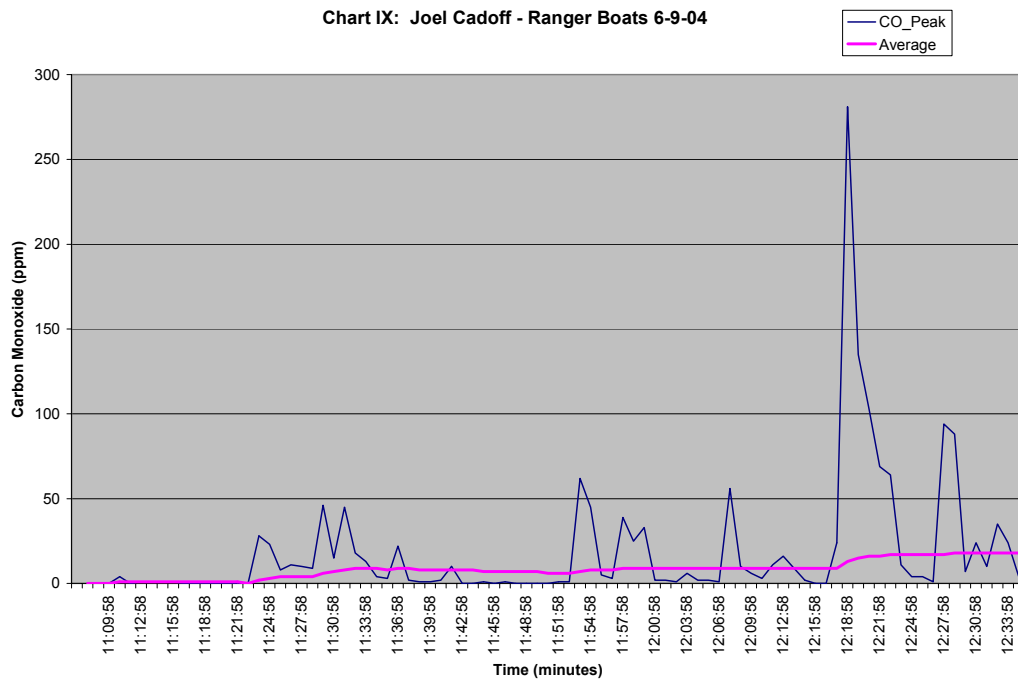


Chart IX: Joel Cadoff - Ranger Boats 6-9-04



For the combination of maintenance activities with Mr. Kinhead and ranger patrol activities with Mr. Tillotson and Mr. Cadoff, Ms. Sahmel's time-weighted average exposure was 14 ppm, with a peak exposure of 800 ppm on the maintenance barge and 454 ppm in the cabin of the cabin cruiser. Mr. Bleicher's time-weighted average exposure was 11 ppm with a peak exposure of 463 ppm on the maintenance barge and 246 ppm on the ranger boats.

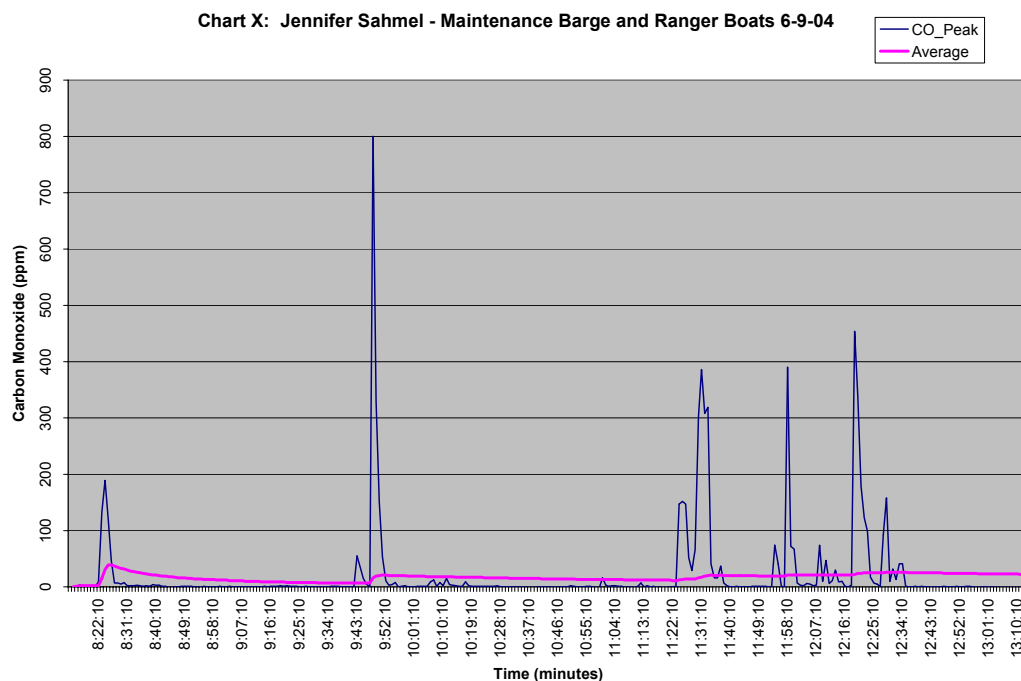
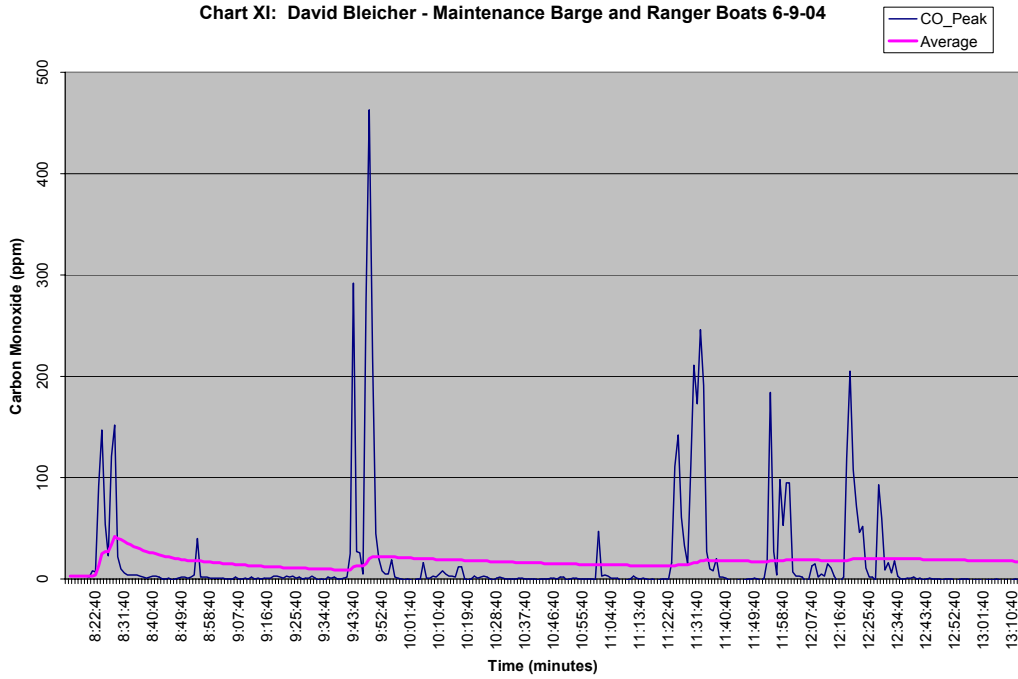


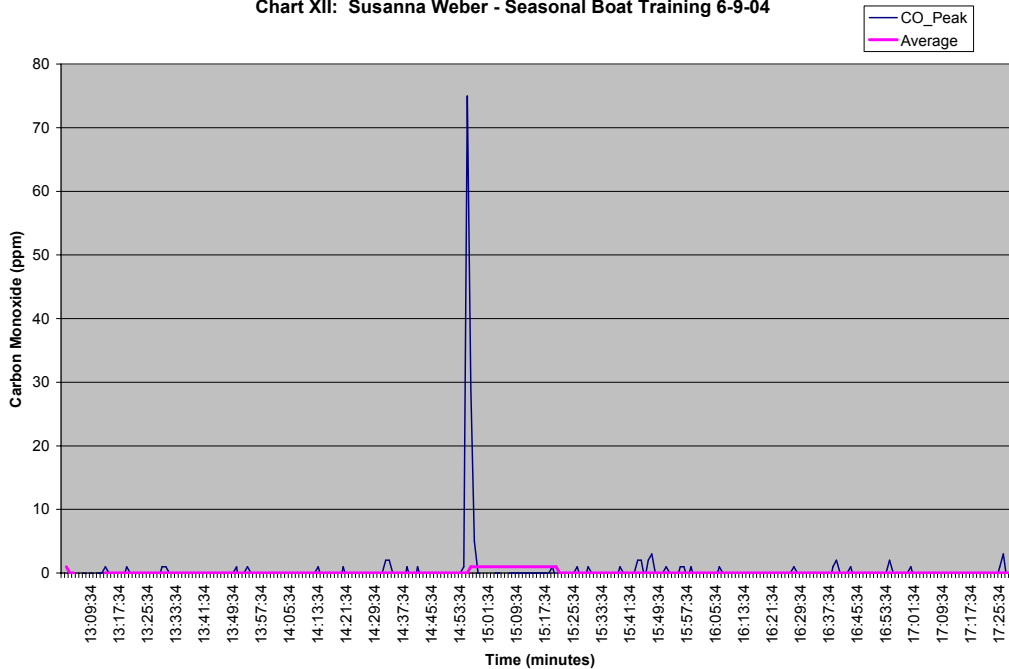
Chart XI: David Bleicher - Maintenance Barge and Ranger Boats 6-9-04



## 6. Seasonal Boat Training

Seasonal boat training was being conducted at the park on June 9. Two of the students, Colleen Ross and Susanna Weber, volunteered to monitor their CO exposure during the course, which involved both training time on land and in a boat. During the June 9 class sessions, Ms. Ross did not actually get onto any of the park boats. Ms. Weber did spend some time on a boat, and had some CO exposure during the training. Her peak exposure during the training was 70 ppm. Please see Chart XII for Ms. Weber's complete exposure.

Chart XII: Susanna Weber - Seasonal Boat Training 6-9-04



## C. CONCLUSIONS AND RECOMMENDATIONS

### General Conclusions

Based on the CO exposure data collected at Curecanti on June 8-9, 2004, there is a very real potential for excessive CO exposure during boating operations at the park. During the two days of monitoring, no individual exceeded any of the full-shift (8 hour) time-weighted average exposure limits for CO, including the OHSA PEL. However, exposures frequently exceeded the NIOSH Ceiling REL of 200 ppm for instantaneous exposure. Additionally, certain scenarios and activities demonstrated a high risk for CO exposure. These included:

- **On the maintenance barge during startup:** CO levels during startup of the maintenance barge reached over 800 ppm within several seconds, an extremely dangerous level.
- **In the cabin of the cabin cruiser ranger boat:** CO levels in the cabin of the cabin cruiser spiked up to 376 ppm during idling on the reservoir when the wind direction was from the back of the boat.
- **In the maintenance shop if the test tank ventilation system is turned off:** in the maintenance shop, CO levels spiked up to 277 ppm within only 5 seconds if a boat engine was idled in the shop without the test tank ventilation system on.
- **On the ranger patrol boats on the Blue Mesa Reservoir for certain wind directions:** On the ranger patrol boats in the operator area, levels spiked as high as 380 ppm *at the operator* location *and as high as 450 ppm in the cabin*, during routine patrols, especially when the wind blew from the back of the boat.

## Recommendations

The following recommendations should reduce employee exposures to CO during boating activities. In particular, because CO is odorless and colorless, it is important to reduce unknown exposures to CO.

- The maintenance barge should be taken out of service and modified *or updated* as soon as possible to lower CO exposures during startup. CO exposure levels for the operator were very dangerous, and were measured at four times the NIOSH Ceiling REL of 200 ppm. Changing out the engines is the most likely modification that will effectively reduce CO exposures, although other modifications may also be effective.
- Inform all employees, volunteers, and contractors that the exhaust odor from the boat engines on almost all of the boats monitored is closely linked to CO levels on the boat. The more intense the exhaust smell, the higher the CO concentration. In general, when an exhaust odor was present on a boat during monitoring, CO concentrations were frequently in the range of 200 ppm, or equivalent to the NIOSH Ceiling REL.
- Inform all employees, volunteers, and contractors that wind direction appears to have a strong effect on CO exposures and concentrations on the ranger patrol boats and other boats on the reservoir. According to the rangers, the wind speeds on the Blue Mesa Reservoir are commonly in the range of 35-40 mph. Even at these speeds, CO levels would quickly build up in the operator area of the boat to well above 200 ppm when the wind *is* blowing directly into the boat from the rear. This is of especially high concern for the cabin cruiser, because CO levels can build up and remain high in this enclosed space at dangerous levels.
- Install marine CO detectors on all boats at Curecanti. These should have an audible and visible alarm to alert the operator when CO levels become dangerously high on the boat.
- *Ensure that the park's boat preventive maintenance program considers all CO exposure concerns and issues as appropriate, and that boat engines with high CO levels (primarily carbureted engines) are prioritized for replacement.*

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Please do not hesitate to contact Jennifer Sahmel at (303) 969-2702 in the IMR Risk Management Office or David Bleicher *at (202) 513-7224* in the NPS Washington Risk Management Office if you have any questions or need additional information on any of the issues presented in this report, or if there are any other questions or concerns that can be addressed by the Risk Management Office.